Experimenting with Data

CHAPTER 1

Experimenting with data: 'Collaboration' as method and practice in an interdisciplinary public health project.

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Interdisciplinary data practices of air pollution

> What is air pollution? That is a great question. What is a weed? A plant in the wrong place. What is dirt? Matter in the wrong place. Pollution is, gases and particles in the wrong place (Peter, Interview 6th November 2011).
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> The problem is that the modelled and monitored data aren't measuring quite *the same thing*, we are not going to have the gold standard and *we are not comparing like for like* and it is a struggle to try and address this (PI, Liaison meeting 2nd April 2012- emphasis added).

Air is something we are embedded in and entangled with, whilst, at the same time, problematic to visualise and sense, always eluding the boundaries we attempt to build and fix it with. Air's lapsing of spatial, temporal and analytical scales is interesting ethnographically, particularly in scientific knowledge making because of the difficulty of materialising and measuring air in any authoritative way (Choy, 2012; Shapin and Schaffer, 1985). During my fieldwork with an interdisciplinary scientific project called Weather Health and Air Pollution (WHAP)[1], different disciplinary approaches did not simply provide 'another perspective', and rather than negotiating different epistemologies of air pollution as uncertain and ambiguous, I found researchers were engaged in, what I have come to refer to as, 'modes of experimenting'. In this chapter, I explore the different scientific practices which construct air pollution as a research object, tracing the ways in which these contingent 'versions of air' were negotiated and re-configured in the process of stabilising a shared air pollution.

Experimenting was both a sensibility and a series of practices, carried out through the making, sharing and re-use of 'data'. The concept of experiment has been subject to examination in the history of science (Shapin and Schaffer, 1985), social and cultural studies of science (Knorr-Cetina, 1981; 1999; Rheinberger, 1994; 1997) and more recently as a way of thinking about interdisciplinary research endeavours (Fitzgerald and Callard, 2014). In many sociological accounts of science, the concept has been used to empirically explore and theorise about the uncertain nature of socio-technical relations in the making. As Stengers (2005) and Rheinberger (1994) have described, experimenting allows us to pose new kinds of questions, and can enable us to speak and think otherwise about non-human entities. I found that it was these modes of experimenting which enabled researchers to explicitly engage with difference and multiplicity, and to think about others' ways of knowing and doing in creative and productive ways.

STS and recent Anthropological approaches to ontology (De la Cadena et al., 2015) suggest that when one focuses on practices and takes seriously material agency other kinds of access points to the worlds of informants are made possible (Gad et al., 2015: 74). I found that data were informational and material forms which all researchers were involved in making, as well as the means by which scientists communicated, contested and conceptualised knowledge making between different fields of practice. As the second opening quote

[1] All names are pseudonyms

highlights, data are embedded in heterogeneous relations, involving, for example, particular kinds of devices to sense and materialise air pollution. To study air pollution collaboratively, as an interdisciplinary matter of concern was problematic because different data practices (what scientists made, used and shared) enacted different versions of air pollution. Because of the relational nature of data, the articulation of data's material formation also shapes collaborative research relations. This shifts cross-disciplinary scientific practices into what can be characterised as an experimental mode. As Knorr-Cetina describes, the structure of knowledge-making is entangled with the social relations of research:

> […] the experiment becomes constituted as a distinctive and powerful structure in its own right […] it is the work of rearranging the social order, of breaking components out of other ontologies and of configuring, with them, a new structural form. The repackaging of efforts accomplished during the birth of a new experiment is also the repackaging of social composition and the creation of a new form of life (1999: 214).

That data were ontologically distinct things in WHAP meant that working with and through multiple data were moments where new constructions, social compositions and forms of life could also potentially emerge.

This is also the case for the ethnographer, where difference and uncertainty are not only intriguing, but may also be fruitful in their ability to generate more creative ways of thinking about field sites. Ultimately, multiplicity was an ethnographic tool which enabled me to configure a sense of 'otherness' in the field, so that differences between and within data practices became my ethnographic focus. Taking data practices seriously, and as interesting anthropologically, also extended what counted as 'the field' during my research. Explicit attention to practices of making data offered an ethnographic vantage point from which to consider data 'from within', rather than as externally bounded forms. In this way, data practices emerged as both an analytical and empirical figure in my research.

As Fitzgerald et al. (2014) have shown, experimenting is particularly applicable to interdisciplinary relations, or 'interdisciplinary assemblages', because it is in such arrangements that the boundaries between disciplines become fuzzy, and the affective and practical relations which hold these together more pronounced. Indeed, it was the articulation and management of difference through the multiplicity of data practices which captured my attention: for how does this seemingly 'successful research team'[2] function in practice, when there are tensions between ways of making data of air pollution and articulating air pollution through data?

From 'translation' and 'difference', to 'equivocation'

Studies of epistemic difference in other fields of collaborative inquiry have proposed a number of ways in which tensions are managed and worked through in practice. Star's concept of 'boundary objects' has been the principal means of describing translation across very different kinds of fields of practice (Fujimura, 1992; Star and Griesemer, 1989; Star, 2010). In such analyses, the metaphor of trade and exchange across borders has been dominant (See, for example, Galison, 1996), where the role of boundary objects enable epistemological dialogue, and thereby the movement and mutual construction of knowledge. There has been less focus, however, on the role of boundary objects in the making and re-making of the boundaries between human and non-human relations in interdisciplinary research. These kinds of entanglements were fundamental in the co-ordination of different fields of practice in WHAP.

[2] The senior researchers on WHAP had worked together previously on various research projects and throughout the duration of the WHAP project they successfully received further collaborative grants.

In WHAP, there were a number of boundary objects or 'shared values'. Health was used by researchers' in their explanations of their role and reasons for participating in an interdisciplinary project. Research about health was an unquestioned 'good' and therefore working on a public health project a socially and politically imbued act. Air pollution was a means of linking up 'the environment' and 'human health', a useful coupling to orientate and justify the interdisciplinary nature of the project. However, although air pollution and health as shared matters of concern worked rhetorically, they functioned less well in everyday practice. As I have highlighted, in data practices air pollution was conceptualised, articulated and materialised in multiple ways, which meant that researchers on WHAP were not only engaging with different epistemologies of air pollution but with different kinds of air pollution altogether (Law, 2004; Mol, 2002).

Another way of approaching difference has been through the concept of 'co-ordination', which foregrounds the ontological dimensions of managing multiplicity in practice. As Mol's (2002) ethnography of how the disease atherosclerosis is practiced and enacted by patients and clinicians has detailed so nicely, different versions of objects can also be made to 'hang together'[3], in ways that do not imply fragmentation. Yet, our empirical problem remains rather different, because the aim of the interdisciplinary project was to produce shared knowledge on a singular air pollution, so that rather than co-ordination researchers confronted difference 'head on'.

Viveiros de Castro's concept of 'equivocation'[4] may be more appropriate for this 'studying of studying difference', for it enables the consideration of the material and ontological work of objects in the making, where what objects 'are' are also subject to boundary work. Thus, rather than epistemological impasse, where different perspectives represent a singular phenomenon in the world, equivocation suggests that the same epistemological term can be used to refer to different things (Viveiros de Castro, 2004a). This shifting of the anthropologist's focus can be useful for thinking through the multiplicity of research worlds which make up WHAP, rather than supposing a constant epistemology and variable ontologies, the same representations and other objects, a single meaning and multiple referents (Viveiros de Castro, 2004b: 6). Indeed, on using the concept in her research on indigenous cosmopolitics, De la Cadena shows how equivocation can bring into conversation a view from different worlds, and as a result extend anthropological knowledge production:

> Thinking about Andean mountains as sites of equivocation that enable circuits between partially connected worlds without creating a unified system of activism, can build awareness of the also partially connected alliances between environmentalists and indigenous politicians in Andean countries, allowing for more than their definition as a movement for cultural or environmental rights (2010: 351).

In this way, approaching scientific research as one configured by cosmopolitics rather than the politics of knowledge permits the anthropologist to extend rather than narrow the relations they follow, and thereby the partial connections they make through and with emergent research worlds.

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[3] Mol looks at the day-to-day diagnosis and treatment of atherosclerosis to examine the ways in which the disease is made to cohere through a range of tactics including transporting forms and files, making images, holding case conferences, and conducting doctor-patient conversations.

[4] 'Equivocation' is a concept coined by anthropologist Viveiros de Castro to make the case for the contribution of 'Amerindian Perspectivism' to anthropological theory. He argues that anthropology's defining problem consists less in determining which social relations constitute its object, and much more in asking what its object constitutes as a social relation: "In this sense, perspectivism is not relativism as we know it—a subjective or cultural relativism—but an objective or natural relativism—a multinaturalism" (Viveiros de Castro, 2004b: 6)

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‘Data’ as fieldwork device: attuning to practices of experimenting

The WHAP project was based across several universities in the UK and their research co-ordinated as part of the ‘Environmental Health’ initiative of a leading UK research council. This was a joint research programme between several other research councils and, as one senior researcher on the project explained, one of the first to combine ‘human health’ and ‘the natural environment’ in their call for bids. This required joining forces with several institutions and drawing upon different disciplinary expertise, including those of epidemiologists, atmospheric chemists, environmental chemists, building physicists, sociologists and an anthropologist. The interdisciplinary shape of the project was something researchers reflected on in my discussions with them and was enthusiastically dawn upon to characterise the “trail-blazing” nature of the WHAP project.

Nonetheless, my role as ethnographer on WHAP was rather ambiguous. My PhD research was framed in the project protocol as an ‘independent component’ of the project. In this way I was not expected to formally contribute to the project outputs, nor participate to the production of knowledge on air pollution. My role was described as “producing knowledge on the knowledge production process”. The contribution of this research was therefore assumed to be ‘unscientific’ because it focused on the relations of the team of scientists, rather than the technological and material relations of air pollution. However, as my discussions of the data entanglements making up the WHAP project will highlight, interdisciplinary engagements are also socio-material processes, and it was the division between ‘administrative’ and ‘technical’ work (in the organisation of meetings, over emails and in terms of ‘who’ gets counted in these communication practices), and the instigation of disciplinary or institutional boundaries in particular moments, which demonstrated the ways in which distinctions, and thereby partiality, also compose, comprise and sustain interdisciplinary research relations.

Fieldwork involved attending weekly meetings, bi-annual ‘collaborators meetings’ (where we physically met at alternate institutions); following email threads and the online sharing of documents; physically moving between institutional sites, both within and external to the project, observing different data-making practices across these, and tracing the material work of sharing and re-using data in the project. As the ‘social science’ component of interdisciplinary relations, I was both a data producer and field site enabler. My very presence on the project was part of doing collaborative interdisciplinary research and reflecting on this process considered a legitimate and perhaps valuable process. It was this simultaneous difficulty of carving out a field site on the project of which I was officially a member that led me to consider the meaning and affect of ‘collaboration’ as a scientific relation. As such, following data were also a way for me to move between situated practices, and functioned as particularly good devices because they were not only the end point of research but the very ‘stuff’ of researching. Data became a fieldwork device, functioning as a legitimate object of concern - being both the everyday labour of science as well as the form scientific output takes - and as a material form through which I could articulate and make active anthropological knowledge making.

An interdisciplinary tension

> It was another weekly meeting, and everyone was gathered round the table in the basement meeting room at The University. General chatter livens up the sparse, white room, and coffee is being poured and distributed. The usual technical issues of the web-conferencing software are being worked out before the meeting begins. The meeting agenda lists a major item for discussion, something that has been taking

> shape for the last six months or so, and which requires the contributions of all the researchers on the project: 'the modelled and monitored data issue'. Everyone quietens down as the PI speaks slowly and clearly into the microphone to check whether 'the modellers' are there – "can they see and hear us all from 400 miles away?" They can. The PI [an epidemiologist] begins by detailing the main discussion item for today's meeting, how we are going to use modelled and monitored in the project? He explains that they, the epidemiologists need to use measures of air pollution to work out the relationship between levels of air pollution and negative health effects, and that they are unsure about using modelled data in their analysis, because, "as epis[5], what we trust is when we see measurements, because we see it and we know how it works and that is a version of reality". The modellers - a group of three today - start murmuring a response, and with a slightly exasperated sigh, Elizabeth [co-PI and atmospheric chemist] states: "the measurements made by monitors do not take into account the different chemical processes which make up concentrations of pollutants". There is a silence which seems resistant to further discussion. To break this sense of impasse, the PI suggests that the team creates a shared document, starting out with the epidemiologists' perspective, in order to conceptualise how we are thinking about air pollution on the project. (Liaison meeting 18th May 2012).

In this anecdote, claims to 'reality' and 'the truth' about air pollution are framed as relative, relating to different kinds of data. Indeed, the PI concludes that "you [modellers] might say it [monitored data] doesn't represent all these different things, but epidemiologists don't trust models, and the modellers, you say, you don't trust the single point measurements". However, this reduction of different to data as informational forms occludes wider ontological dimensions of the tension between data, which wasn't about trusting either data more or less, but about what kinds of relations make up air in knowledge practices.

Modelling and monitoring practices are different ways of making data of air pollution. Each involves an instrument to make a numerical measure of the amount (a concentration) of a particular air pollutant in an air sample under certain conditions. What is of interest for each practice is, in the first place, air rather than air pollution: how to 'capture' it (monitoring) and how to 'simulate' it (modelling). It is the measurement contexts, including temperature, time of day, season, location, for example, that make the measurement meaningful and, as a result, 'data'. Working out the right relations of air was one of the key components of making data of air pollution, and these are different for modelling and monitoring. In comparing the ways in which numerical readings were made, I found that different enactments of air pollution emerged as a result of particular research practices which make up data.

Monitored data and modelled data

Making monitoring data of air pollution involves placing monitors in strategic locations, often in areas considered as having high levels of urban pollution. The stations are small cabins comprising a number of different monitors, each of which measure specific pollutants. These monitors draw samples of surrounding air in through tubes which connect the inside of the station to the world outside. Once in the tubes, the air sample goes through a process of purification, where the 'wrong' parts of air are taken away with a scrubbing device, so that the relations of interest - a particular pollutant - are separated and measured by the sensor inside the monitor (Garnett 2016). The sensor functions by the passing of a UV light beam through the tube and the measure of the pollutant is the measure of the reaction which results from this process. A series of fluctuating numbers - unstable measurements - are shown on the

[5] The term 'epis' was the shorthand name used to refer to the epidemiologists on WHAP.

screen on the front of the monitor, and in order to turn these numbers into data the numerical readings are checked to ensure they have not been unduly influenced by the instrument used.

Making modelled data is a different kind of practice and has a different kind of material situatedness to monitoring. Yet there were also resonances with monitoring, in terms of the processes and transformations through which the numerical measurements became data. Both practices attend to the construction and control of the setting from which a measurement can be made. For modelling, the measurement setting was built with computer code, so the complexities which make up a controlled environment, such as temperature, weather conditions, time, were also pre-conceived and constructed within the model. This contrasts with monitoring, where the complexities in making a measurement influenced the setting in which the monitor was located. In monitoring, data other than air pollution are also collected and recorded, including the temperature in the monitoring station, the technician's tests and their results and details of the kind of air being measured at this site (e.g. is it 'road side'?), which contextualises the reading taken so it can become meaningful data.

Rather than taking away other parts of air, modelling adds relations to air through the building and running of a computer simulation of the atmosphere, in which air pollution is measured as composing and comprised by physical and chemical interactions . Air pollution is abstracted in a different ways here, and thereby requires different contextual information in order to make data meaningful and translatable beyond the research setting. Making modelled data was framed by a logic of knowing not just air pollution, but air pollution in the atmosphere, a three dimensional form in flux and in process and therefore as something which articulates with a scale of global governance and regulation.

Different data, different air pollutions

> Data too need to be understood as framed and framing, understood, that is, according to the uses to which they are and can be put. Indeed, the seemingly indispensable misperception that data are never raw seems to be one way in which data are forever contextualised – that is, framed – according to the mythology of their own supposed decontextualisation (Gitelman and Jackson: 6).

I have shown that modelling and monitoring data practices, as particular engagements with the world, enact different versions of air pollution in practice (Mol, 2002). Specifically, I've delineated how modelling and monitoring configure air pollutions differently, by transforming numerical readings into data in ways that make it meaningful: the particular arranging and articulating of 'the measurement setting' sets the scale and mobilises the right kinds of relations. In other words, numbers became numerical data through 'framing', by materialising and making tangible a context of air pollution which can be translated into the measurement setting, even if this ultimately involves taking away that context in the process of stabilising data.

I have exemplified these framing practices in detailing the making of modelled and monitored data, where the transformation of a numerical reading to data rely on a number of different kinds of relations and attachments - from assemblages of sensing, theories about reality, disciplinary norms, to technologies of representing and communicating data. Data were epistemologically similar in the sense that they were something that could be understood by other researchers as the outputs of scientific work. Furthermore, their ability to act as 'other' meant they were also used to potentially shed light on situated and contingent nature of data practices. Data seems to have currency in the project, with the capacity to extend research questions and the material and conceptual boundaries of phenomena under question. Most significantly, however, data was also framed by researchers as 'standing in' for

phenomena (i.e. representations of air pollution which can be intervened with). As such, there is something about data which shapes the ways in which the empirical and conceptual problem of studying a shared air pollution plays out. By thinking about data as a mode of doing interdisciplinary research - as a methodological device for all researchers on WHAP - data's material expression becomes paramount.

That there was no shared articulation of air pollution in the WHAP project meant a space was also left open within which air pollution could be (re)configured together. Indeed, as a result of the multiplicity of data on air pollution, just how data were materialised and expressed became a shared concern, both for myself and other researchers, so that the very practices, processes and materiality of making data were of empirical interest. That there were multiple ways in which air pollution was enacted through data practices meant that data were also a way to materially engage with different air pollutions. Data, then, overflow the observational conventions of scientific practice and also the observational and participatory conventions of ethnography. It wasn't that I was participating in data practices, but my own data practices were put into question, mobilised and re-configured, primarily because other researchers also didn't take data as a 'natural given', and therefore becoming ethnographically interesting.

Experimenting with data

Data were not only an everyday concern, but the material form through which the team communicated both with myself and other researchers. For example, the visualisation of data, as maps of air pollutant concentrations across the UK, or time series graphs of observational and modelled results, produced a shared work space, where different articulations of air pollution through data could be considered together. Graphs also imply a singular world and thereby making, contesting and re-doing maps a very explicit process of configuring a shared research world for studying air pollution. In a similar way, the boundaries of space took the form of the '5x5km grid square' across different data practices, which functioned as the empirical, spatial contours within which air was to be studied and data of air pollution made.

Primarily, the way in which air pollution was experimented with was by making additional new data. This was done in two ways: first, by using small sensors, referred to as DIY instruments, which could be manually placed in particular locations to measure air pollution at particular points in time (on a smaller scale to monitoring stations); and, second, by comparing modelled and monitored data of air pollution in a statistical model. Both these new kinds of data practices experimented with air pollution in explicitly collaborative and interdisciplinary ways.

DIY data and the spatial heterogeneity of air pollution

> Another area is variation of exposure within grid square, and that's only something our additional measurements could get some sort of handle on, and to examine ways in which variations,of days with high Ozone vary within a grid square […] But still it is possible to get an idea of the magnitude of variability and whether anything in particular drives this so that we could do something more systematic about what's going on within a grid square (PI, Liaison meeting 2nd April 2012).

The collection of 'DIY measurements' by the environmental chemists (in close liaison with the modellers and epidemiologists) was a way to generate multiple measurements of air pollution at a finer scale to those made by the model and the monitor. These additional measurements were used as a way to understand air pollution and its heterogeneity within the spatial remits materialised by the modelled and monitored data. DIY instruments were manually placed at

particular spatial and temporal points in a geographical area, with the purpose of providing information on the air pollution that monitors and models are not measuring - its spatial heterogeneity. The DIY instruments function by measuring the absorption of a pollutant in a gauze, soaked in a special chemical mixture placed at the top of the tube. Like monitors, the instruments absorb the pollutant being measured for. In a monitoring station these are measured by UV light, in DIY data practices they are measured in the laboratory.

This experiment took place in one city in the UK, and involved making lots of measurements of air pollution at different points in time and space. This was aided by a process called 'conditioning' involving the use of an open source software tool (analysing air) to 'characterise the data further'. The tool enabled the modelled data, monitored data and DIY data to be compared together as a way to produce a graphic of multiple data of air pollution.

The new data enabled the comparison of modelled and monitored data by expanding the empirical detail and material form of air pollution as a research object. The process highlights the different informational value data offer, but also their material intervention in the process of working out what air pollution is. The DIY data were a way to get a sense of air pollution beyond the spatial and temporal remits of the modelled and monitored data. In this way, experimenting offered purchase on data practices as well as expanding the empirical remit of air pollution research.

Statistical data on modelled and monitored data

A second way modelled and monitored data were experimented with was through the making of statistical data of data by the epidemiologists on WHAP. By running a statistical model on Excel, using old modelled and monitored data sets, new data on air pollution were made. There are about ninety monitoring sites in the UK, which means there are only a few locations where you can directly compare monitored data with modelled data.

Comparing these old sets of modelled and monitored data was a way to work out whether the model or monitor produces better data according to statistical values of confidence and error. By measuring the error in modelled and monitored data, a new data set was made with error statistically removed. These statistically 'true data' were used as a reference to judge modelled and monitored data's ability to measure air pollution in spaces where humans breathe,: error effects how health effects of air pollution are measured (Garnett 2016).

The new data of data were the material means by which the epidemiologists came to anticipate and evidence error on their own terms. In this way, experimenting with data in the statistical model enabled the extension of what data can do and mean beyond that of the on-site production of modelled and monitored data. Error was re-represented in Excel, only to become a particular component of a formula through which it can subsequently be statistically removed. These statistical practices shifted the focus from what was talked about as a problem of representation, to the material means by which a statistical solution could then be generated in order to frame data in a way which would enable health claims to be made. In this way, the statistical data of data were able to intervene in the modelled and monitored data tension, articulating air pollution in a new locally contingent way.

Multiple data and the making of a singular air pollution

> The epidemiologists suggest using both modelled and monitored data according to the results of the simulation study and DIY data. This would mean using modelled data for

> some pollutants and monitored data for others […] Modelled and monitored data are juxtaposed in a table showing the simulation study results, as a visual comparison and a means to distinguish which data should be used for which pollutants. (Team meeting 13th June 2013).

It was suggested that the epidemiological analysis would become the hybrid space where different data are used for different pollutants in separate analyses. Using different data of different pollutants in separate analyses was a way to produce data on air pollution and health whilst avoiding ontological anxiety). The *DIY data* and *statistical data* were both situated as part of an emergent interdisciplinary space. These were characterised by collaborative attempts of interdisciplinary-coherence; explicitly responding to non-local values and recognising the practical, material demands of data's re-use within the wider project. This work of experimenting brought modelled and monitored data into new fields of practice, where their informational and relational capacities could be balanced in relation to a collaborative affective sensibility.

Subsequent to these productive practices of experimentation, a physical team meeting was organised involving all the scientists and the types of data made and used by WHAP. The team meeting functioned by performing an interdisciplinary response and materially articulating a shared air pollution. Primarily, the tension was reduced to one kind of pollutant: very fine particulate matter ($PM_{2.5}$):

> Recent epidemiological studies have indicated that smaller particles and their components derived from combustion sources (ie, $PM_{2.5}$) are principally responsible for cardiovascular hospitalisations, and is methodologically relevant because $PM_{2.5}$ is internally heterogeneous, and 'there are lots of processes we don't know until they are simulated', which means monitored data becomes redundant (PI, Team Meeting, 13th June 2013).

What worked about $PM_{2.5}$ was its internal heterogeneity, and therefore intrinsic multiplicity. Particulate matter is a pollutant defined by its size: a non-ambiguous material characteristic that does not rely on a situated understanding of atmospheric relations in order to determine its toxicity. Second, particulate matter is lots of kinds of particles, therefore giving scope and potential for both modelled and monitored data to contribute to its representation. Third, there is scientific consensus around its related negative health effects. Most significantly, however, is that the computer model is the only method for measuring $PM_{2.5}$ because the monitor data does not distinguish between particles over 10 micrometres (PM_{10}) in diameter and 0.25 micrometres in diameter ($PM_{2.5}$). $PM_{2.5}$, then, carried both wider meaning in terms of the configuring of new relations between air pollution and health as an epidemiological object of concern, whilst appealing to the particular research interests' of the atmospheric chemists and the technical and theoretical potential of their model.

The role $PM_{2.5}$ played in the material negotiations between the modellers and epidemiologists demonstrates a shift from a discourse of representation to the making of air pollution with data. The particulars of data as *kinds of air pollution* became the object around which the different interests of the epidemiologists and the modellers could be accommodated. The DIY data and statistical data of data did not directly contribute to this new articulation of air pollution, because neither data practice produce comparative data on $PM_{2.5}$. Yet, these experimental data forms did facilitate the process of co-ordination because they enabled researchers to do more than simply share data. Extending beyond epistemic relations, the *DIY data* and *statistical data* intervened in the tension around what data to use, and therefore the kind of air pollution to study. Through these experimental negotiations the tension shifted in form and focus, so that researchers were engaged in working out what kind

of air pollution to study rather than what data to use. By foregrounding the multiplicity of air pollution and taking seriously different data practices air pollution was enacted in new ways. The intervening data enlivened and materialised data in ways that engaged with difference, so that difference was not just made to 'hang together' but a new configuration of the research object emerged as a result.

Composing a 'common air'

> […] setting up comparison or connecting bits of information previously unrelated performs cultural work. So do click throughs. Zooming in and out, learning to consider the implications of scale involves what Antonio Gramsci termed 'elaboration', the labour of working out common sense. This kind of labour can't be reproductive. It involves a play of signs and systems that is always unsettling (Fortun, 2012: 322).

As Fortun's study of environmental information systems suggests, information is playing an increasingly performative role. The process of 'informatting the environment' points to the possibilities for its constant reordering and revisualisation. In light of the non-humanist materialities emphasised in recent science studies research, however, I argue that Fortun's focus of informatting technologies also highlights the performance of natures-cultures which make up interfaces between phenomena of research, science and politics. Indeed, new technologies and ways of collecting and using information means considering the ways in which the material qualities (Barad, 2003; Ingold, 2007) of phenomena play out in different actions and interactions.

During the WHAP team meeting the experimental data took centre stage, and their visualisation in graphs and tables configured a collaborative research space. Both these practices of experimenting with data - the DIY data and statistical data of data - meant the research object air pollution could be set in motion and re-configured. Data were an effect of certain forms of socio-material relationships that we could call collaboration. Air pollution was always in emergence rather than a singular, stable or tangible thing, and data were thereby a means to move with and through these relational practices and processes. As a result, there were a number of research objects on WHAP-in the form of material traces, numbers and graphics -and their transformation into different data the moments when multiplicity was materialised and articulated for researchers on WHAP.

By producing ethnographic data on making and intervening with multiple data I was able to trace how difference emerges, and thereby make symmetrical the multiplicity of air pollution in practice. The work of experimenting with data was a way to trace the unfolding of the interdisciplinary tension and also 'slow down' (Stengers, 2011) my own research practices. As a result, rather than focus only on the network of relations which materialise a stable research object, I have foreground the experienced, playful and affective dimension of these. I also developed my own analysis of science in action, alongside the researchers on WHAP. Making data of air pollution were situated practices, but during modes of experimentation these entanglements became collaborative processes which extended along the multiplicity of data practices making-up WHAP.

De la Cadena claims that it is the visibility of hybridity that leads to potential awareness of our analytical categories as equivocations. Researchers were actively working with different articulations of air pollution, and these were made explicit during experimenting and the unfolding of the interdisciplinary tension. The multiplicity of air pollution in data practices was a finding which led researchers to explicitly bring difference to the fore, as an active component of interdisciplinary knowledge making. The process of translation through data for the researchers on WHAP is productive along similar lines to those described by De la Cadena. By acknowledging the difference between particular materialisations of air pollution, a view of these different research worlds materialised, which changed the definition of the

tension analytically: from one about epistemology to its ontological dimensions. Moreover, experimenting extended the empirical and conceptual remit of air pollution as a research object, so that studying it became more than a process of stabilising a relationship between an instrument and an air sample, and ultimately involved reflecting on, acting with, and re-configuring that very relationship. This was a process which involved re-constituting modes of making data and therefore enabling new articulations of air pollution.

Experimenting with data as an anthropologist

Experimenting with data was, then, a material and conceptual process of testing the capacities of data to generate new articulations of air pollution. If air pollution is 'equivocation', experimenting with data was the means by which different air pollutions were brought together and partially aligned. Following data and experimental practices was not only a way to study the material work of interdisciplinary knowledge production, but an empirical process of coming to sense and appreciate the reflexive work and care[6] which 'sharing data' and doing interdisciplinarity comprises. This is perhaps something anthropologists can learn from, where the affective labour and sensibilities which underpin collaborative ways of doing and knowing are managed and co-ordinated rather successfully through material, practical work.

Part of this tentative process of configuring a shared air pollution meant my own fieldwork practices shifted and adapted too. As I have already suggested, my research intervened in the research process. I contributed to the multiplicity of data practices on WHAP, making lateral relations between different data in my own data practices. The material work of studying air pollution through data also de-stabilised my role as an anthropologist. In many ways, my role as anthropologist was made obsolete, as other researchers on WHAP did their own ethnographic fieldwork and reflexively sought to understand and work with epistemological and ontological differences in analytical and empirical ways. This has been referred to as para-ethnography (Marcus, 2013), as situations where the anthropologist and informant are difficult to distinguish in any epistemic sense. By thinking with this notion of experiment, I suggest that para-ethnography can also be understood as the mutual study of world-makings.

I have re-narrated this shift from epistemology and ontology through tracing my ethnographic encounter with data. For example, when data's form and meaning were contested in their movement to other practices I came to appreciate data as air pollutions, rather than, say, representations of the phenomena in question. Following data required me to take data seriously as forms which have the capacity to effect and affect, and thereby overflow their own material and conceptual contours. As such, data had a multiplying effect, as emergent articulations of air pollution (as both material and conceptual processes) which were not necessarily the outcome of scientific working but constitutive of it. Such an experimental mode of ethnographic engagement can be understood as more fluid, as an emergent set of relations between scientists, non-human forms, the material arrangement of research settings and ethnographer. Becoming a part of these experimental moments meant that, for example, it was the very instruments and sensing practices which also became key informants (Traweek, 1988). This enabled me to pose new kinds of questions, on the nature of interdisciplinary inquiry and about the kind of anthropological knowledge I was making as a result.

I extend the notion of para-ethnography, to incorporate the embodied, material and sensory dimensions of working across difference and the taking seriously of others' ways of doing research and intervening in research worlds. As a result, I was not producing an account

[6] Maria Puig de Bellacasa envisions care as an ethico-political issue for 'ways of knowing', where theories and concepts have ethico-political and affective effects on the perception and re-figuration of matters of fact and sociotechnical assemblages (2011: 87).

of a particular viewpoint, of the modellers or the epidemiologists, but was enfolded in the tension, as a component of doing interdisciplinarity. I was reliant on the capacity of data and experimenting with data to make visible the kinds of human and non-human relations which formed my ethnographic sites. In order to consider data as different kinds of 'things', for example, required me to focus on the material and affective negotiations by which data is stabilised and made meaningful in practice. It was the careful work of moving and using data in particular ways, which led me to appreciate the labour of balancing multiple interests and expectations in a large, multi-sited research collaboration.

Nonetheless, the data I produced was often less tangible than the moving of digital data sets from software to software and their visualised form in graphs and tables like those generated by my co-collaborators. Although I did often re-represent these and make them visible in my own data, as ethnographic subjects in their own right. Researchers also engaged with my narrative accounts of the research process. Indeed, on sharing an ethnographic account of the emergence of the modelled and monitored data tension with the team, several researchers argued that it was not 'a tension' but 'a debate', an on-going dialogue between different fields of practice rather than something fundamentally problematic. Another team member suggested I had perhaps 'over-emphasised the tension'. Indeed, researchers weren't interested in accentuating the tension but rather focussed on ways of managing and resolving it, in very practical ways. This resonated with my experience of research meetings where discussions were not often framed as epistemological but as processes of an on-going practical achievement.

In this particular ethnographic case of interdisciplinary research in action, the ethnographer's view isn't any more 'other' than those of the different scientists. I have shown that the multiple ways of enacting air pollution were not treated in opposition to each other, but as an empirical reality of studying a fluid and indeterminate material formation. The concept of equivocation highlights the ways in which scientists on WHAP treated data of air pollution(s) as different things rather than different perspectives. As such, the anthropological knowledge I made on air pollution as equivocation was part of this process, which mobilised the circuits (via data) between partially existing worlds (different fields of scientific practice), without displacing one discipline (and its data practices) over and above another.

Conclusion

Although air pollution was framed as a complex problem, which required multiple disciplines to study and respond to it, in practice I found air pollution was not revealed further through bringing different perspectives together. Rather, air pollution was configured in new ways through interdisciplinary working. I have focussed specifically on the experimental questions which multiple kinds of data enable in interdisciplinary research because it was the very stability of what counts as 'scientist', 'instrument', 'air pollution' that were under negotiation. 'Experimenting with data' was a mode of collaborating shaped by a set of institutional and disciplinary arrangements, but was also the very shape that material work took. It was the arrangements of data, rather than individual scientists, for example, which enabled the posing of new questions. In accordance with Stengers, it was the work with data which allowed data to 'speak' in particular ways and thereby intervene in, and ultimately coordinate, the multiplicity of air pollution as a research object. Building on Fitzgerald et al's notion of interdisciplinary assemblages, I offer an account which is more materially imbued. It was the multiple data-instrument relations and how these effect and affect one another which come into play in my ethnographic narrative.

The concept of experiment is useful for an anthropological approach to interdisciplinary knowledge making because it offers a material means of ethnographic engagement, whilst bringing to the fore the practical ways in which frictions are managed and harnessed in productive and creative ways. Rather than taking data as the outcome of

interdisciplinary working, practices with data were also moments when non-representational modes of knowledge making emerged. Thus, although I focussed on the explicit material work of by-passing tensions, this was based on the careful management of maintaining research relations and by taking seriously others' ways of knowing, even if this meant working in more-than-disciplinary ways. These experimental data practices were where the materially-informed sensibilities productive for interdisciplinary working played out, which often get silenced in normative, epistemological accounts of interdisciplinary knowledge production. Experimenting with data made multiplicity tangible and therefore emergent forms which could be engaged with by different researchers. So, although different data and different air pollutions were the initial problem, they also formed the basis through which a (temporary) collaborative air pollution was achieved.

Acknowledgments

Special thanks to researcers on the WHAP project whose patience and support made this research possible. Thanks also to Judy Green, Catherine Montgomery and Simon Cohn for guidance during the course of the PhD on which this work is based, and to Tomas Sanchez Criado and Adolfo Estalella for their insightful comments on earlier versions of this chapter. Fieldwork for this research was supported by the Natural Environmental Research Council, UK. Ethical approval was granted by the London School of Hygiene & Tropical Medicine Ethics Committee.

References

Barad K. (2003) Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. *Signs* 28: 801-831.

Choy T. (2012) Air's Substantiations. In: Rajan SK (ed) *Lively Capital.* London: Duke UP, 121-155.

De la Cadena M. (2010) Indigenous Cosmpoloitics in the Andes: Conceptual Reflections beyond "Politics". *Cultural Anthropology* 25: 334–370.

De la Cadena M, Lien ME, Blaser M, et al. (2015) Anthropology and STS: Generative Interfaces. *Hau: Journal of Ethnographic Theory* 5: 437-475.

Fitzgerald D and Callard F. (2014) Social Science and Neuroscience beyond Interdisciplinarity: Experimental Entanglements. *Theory, Culture & Society* 32: 3–32.

Fortun K. (2012) Biopolitics and the Informating of Environmentalism. In: Rajan SK (ed) *Lively Capital: Biotechnologies, Ethics, and Governance in Global Markets.* Durham and London: Duke University Press, 306-329.

Fujimura J. (1992) Crafting science: Standardized packages, boundary objects, and "translation.". In: Pickering A (ed) *Science as culture and practice.* Chicago: University of Chicago Press, 168-211.

Gad C, Bruun Jensen C and Ross Winthereik B. (2015) Practical Ontology: Worlds in STS and Anthropology. *NatureCulture* 3.

Galison P. (1996) Computer Simulations and the Trading Zone. In: Galison P and Stump JD (eds) *The Disunity of Science: Boundaries, Contexts, and Power.* Stanford, California: Stanford University Press.

Ingold T. (2007) Materials against materiality. *Archaeological Dialogues* 14: 1-16.

Knorr-Cetina K. (1981) *The manufacture of knowledge. An essay on the constructivist and contextual nature of science,* Oxford: Pergamon Press.

Knorr-Cetina K. (1999) *Epistemic Cultures: How the sciences make knowledge,* Cambridge, Massachusetts: Harvard University Press.

Law J. (2004) *After Method: Mess in Social Science Research,* London: Routledge.

Marcus G. (2013) Experimental forms for the expression of norms in the ethnography of the contemporary. *Hau. Journal of ethnographic theory* 3: 197-217.

Mol A. (2002) *The body multiple: Ontology in medical practice,* Durham and London: Duke University Press.

Rheinberger HJ. (1994) Experimental Systems: Historiality, Narration, and Deconstruction. *Science in context* 7: 65-81.

Rheinberger HJ. (1997) *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube,* Stanford, CA: Stanford University Press.

Shapin S and Schaffer S. (1985) *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life,* Princeton, NJ: Princeton University Press.

Star S.L. (2010) This is Not a Boundary Object: Reflections on the Origin of a Concept. *Science, Technology and Human Values* 35.

Star S. and Griesemer J. (1989) Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology 1907-39. *Social Studies of Science* 19: 387 - 420.

Stengers I. (2005) The Cosmopolitical Proposal. In: Latour B and Weibel P (eds) *In Making Things Public: Atmospheres of Democracy.* Cambridge, Massachusetts: MIT Press, 994-1003.

Stengers I. (2011) Another science is possible! A plea for slow science. *Inaugural lecture.* Faculté de Philosophie et Lettres, Universite Libre de Bruxelles.

Traweek S. (1988) *Beamtimes and Lifetimes: the World of High Energy Physicists,* London, UK: Harvard University Press.

Viveiros de Castro E. (2004a) Exchanging Perspectives: The Transformation of Objects into Subjects in Amerindian Ontologies. *Common Knowledge* 10: 463-484.

Viveiros de Castro E. (2004b) Perspectival Anthropology and the Method of Controlled Equivocation. *Tipití: Journal of the Society for the Anthropology of Lowland South America* 2: 3-20.